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A SCALE FOR WEIGHING BEEHIVES

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Accurate weight records are necessary to enable a beekeeper to evaluate properly the colony production and the producing capability of a particular location. Some beekeepers keep a colony in the apiary or bee yard on a platform scale. The gain of a single colony in a yard is not a satisfactory way to evaluate that location because of the wide variation in colony strength. This variation can easily produce misleading information as to the true value of the location. The beekeeper should know the gains of each colony for evaluating the colony and the location.

To date, two methods of weighing have been used by the apiculturist and each has its disadvantages. One method is to place each colony in the test on a separate platform scale. The cost of a scale per colony is prohibitive, particularly when a large number of colonies are involved. Therefore, the colonies are either carried to a scale or the scale taken to the colonies for weighing. This requires two men and a considerable amount of time and labor. The other method of weighing is to use a spring scale supported from a tripod so the colonies can be lifted and weighed in place. This equipment is cumbersome and requires two men to perform the weighing operation.

The scale described is reasonable in cost, easy to operate, rugged, and sufficiently accurate for most apicultural requirements. It is designed for easy and quick manipulation by a man. The large diameter wheels and rigid frame make it usable in most bee yards. The speed and ease with which one man can obtain colony weights make it practicable to maintain a frequent weight record of each colony. This permits the beekeeper to make better management decisions.

This scale is built on the principle of a fork lift with a gross capacity of 600 pounds (Figures 1 and 2). It is built rigid enough so weighing can be performed on uneven ground. The complete scale as designed weighs approximately 120 pounds when made of steel, and approximately 100 pounds when made of aluminum. There are three principal parts of the scale--the main frame, the lifting frame, and the weighing or sensing element.

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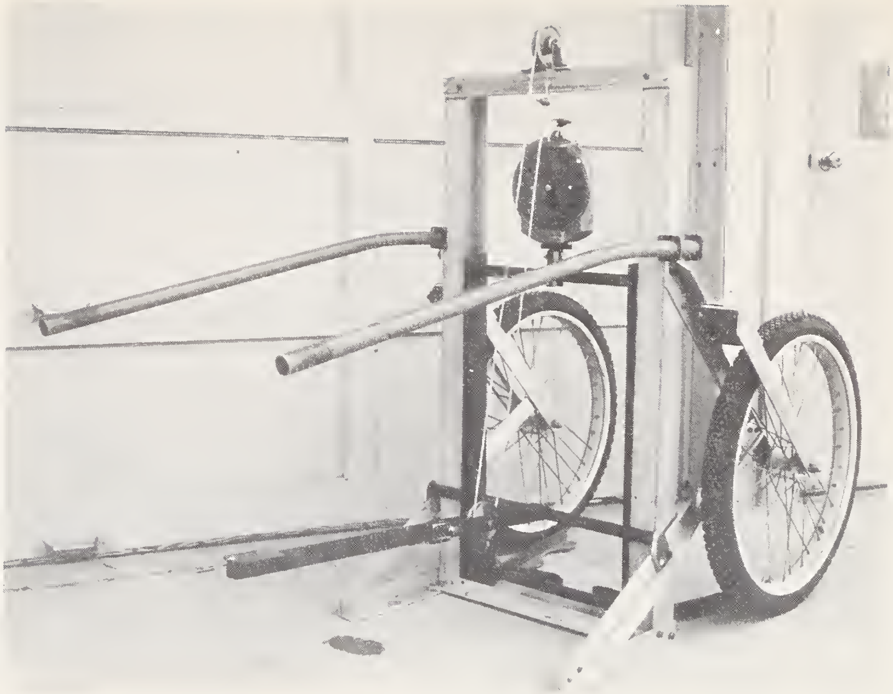

Figure 1.--Rear of hive scale with spring scale. The main frame is aluminum.

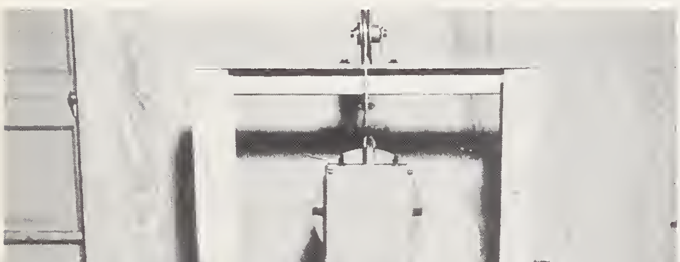

Figure 2.--Front view of hive scale showing movable lifting fingers.

To aid in construction of the scale, the drawings and parts list is divided into two parts--the main frame and the lifting frame. The drawings shown do not agree in every detail with the photographs used, as the photographs are of the experimental models. The item number in the parts list (Table 1) and in the drawing is for the same piece. The materials list gives the total length of each size of metal required for construction (Table 2). The material for each type of lifting finger is listed separately.

TABLE 1.--Parts list for beehive scale

PARTS FOR MAIN FRAME

Item No.	Description	Number Required	Shape	Size	Length (inches)
1	Plat- for foot lift	1	Plate	3x3/16	4
2	Lever for foot lift	2	do.	$1\frac{1}{2}$x3/16	37
3	Handles	2	Conduit	3/4"	38
4	Wheel support, inside	2	Square tubing	11 gage, $1\frac{1}{2}$x$1\frac{1}{2}$	29
5	Wheel support, outside	2	do.	do.	30-1/2
6	Wheels	2	Bicycle	24x2.125	
7	Cable pulleys	2		3" D.	
8	Bracket from hub to frame	4	Plate	$2\frac{1}{2}$x$\frac{1}{4}$	3
9	Brace to wheel support	2	∟	1x1x3/16	15-1/2
10	Bearing bracket for lifting pivot	2	Plate	$2\frac{1}{2}$x$\frac{1}{4}$	4
11	Brace for skids	2	∟	1x1x3/16	17-3/4
12	Skids	2	∟	$1\frac{1}{2}$x$1\frac{1}{2}$x3/16	12
13	Upright guides	2	⊏	2x1x3/16	45-3/4
14	Top braces	1	∟	$1\frac{1}{4}$x$1\frac{1}{4}$x$\frac{1}{4}$	20-1/2
15	Top pulley support	2	Plate	2x$\frac{1}{4}$	2-1/2
16	Pivot for lifting lever	1	Pipe	3/4"	23
17	Bottom brace	1	∟	1x1x3/16	20-1/2
18	Handle brackets	4	Plate	$2\frac{1}{2}$x$\frac{1}{4}$	2-1/2
	Cable, high tensile steel			1/8 or 3/16	96

Table 1.--Continued

PARTS FOR LIFTING FRAME

Item No.	Description	Number Required	Shape	Size	Lengtn (inches)
19	Supporting pieces	4	Plate	1$\frac{1}{2}$x$\frac{1}{4}$	3
20	Bucking bars	2	do.	1x$\frac{1}{4}$	6-1/2
21[1]	Main guide bearings double shield	4		1-5/8 D. 3/4 in. Bore	
22	Fork uprights	2	Plate	2x$\frac{1}{4}$	30
23	Hinges	2	Round	1" CR	4
		2	Bolt	5/8"	4
24	From 23 to 22	2	Plate	1x$\frac{1}{4}$	4
25	Supporting arms	2	do.	1$\frac{1}{2}$x$\frac{1}{4}$	15-3/16
26[1]	Side bearings double shield	2		1-1/8 D. 1/2 in. Bore	
27[1]	Bottom bearing shaft	1	Round	3/4	19-7/8
28[1]	Support for side bearing	8	Plate	1x$\frac{1}{4}$	1-3/8
29[1]	Top shaft	1	Round	1"	19-7/8
22[1]	Uprights	2	Plate	2x$\frac{1}{4}$	29
30[1]	Fingers	2	do.	2x5/8	19-1/2
31[1]	Bucking bar	2	do.	1x3/16	2-1/2
32[1]	Cross support	1	do.	2x$\frac{1}{2}$	17
33[1]	Triangle gusset plates	2	do.	3x$\frac{1}{4}$	4

[1] Use for rigid fork lift.

TABLE 2.--Materials list for beehive scale

Item	Size[1]	Quantity or length
Square tubing	$1\frac{1}{2}$x$1\frac{1}{2}$, 11 gage	10'
Plate	$1\frac{1}{2}$x3/16	62"
	$2\frac{1}{2}$x$\frac{1}{4}$	2'8"
	2x$\frac{1}{4}$	5'5"
Channel	2x1x3/16	7'x8"
Angle	1x1x3/16	7'4"
Angle	$1\frac{1}{4}$x$1\frac{1}{4}$x$\frac{1}{4}$	$20\frac{1}{2}$"
Pipe	3/4	2'
Cable		8'
Bearing, double shield	1-5/8 OD.	4
	1-1/8 OD.	4
Cold roll shafting	1	19-7/8"
	3/4	19-7/8"
Plate	1x$\frac{1}{4}$	11"
Wheels, bicycle	24x2.125	2
Conduit	3/4	6'4"
Movable fingers:		
Plate	$1\frac{1}{2}$x$\frac{1}{4}$	3'
	1x$\frac{1}{4}$	2'
Shaft	1" CR	9"
Bolt	2-5/8	4"

Item	Size[1]	Quantity or length
Fixed fingers:		
Plate	2x5/8	3'4"
	1x3/16	5"
	2x$\frac{1}{2}$	17"
	3x$\frac{1}{4}$	8"

[1] All dimensions in inches unless otherwise noted.

The main frame is built similar to a two-wheeled cart with wheels in front and skids in the rear. Items 1 through 18 of the parts list and drawing (see Figure 3) make up the main frame which consists of wheels, guides, bracing, and the foot lift for raising the movable frame. When the main frame is made of aluminum the guides are made of 3-inch channel, and are of the 2-inch size when steel is used, because 3-inch channel is the smallest commercial size made in aluminum.

Bicycle wheels are used for easy maneuvering of the scale over rough terrain. Balloon-type bicycle wheels are recommended for easy moving in soft terrain and they carry the load better than the narrow bicycle tires. On relatively smooth ground 12 x 2.75-inch light-duty industrial wheels could be used.

The lifting frame consists of the bearings, the moving frame, and the fingers for lifting the hive. The lifting arms shown in Figures 2 and 4 were designed to lift hives with western-type bottom boards. This type of bottom board has 3/4-inch thick cleats under each end. The hive lifting arms for the western bottom board are hinged to close in from the side with fingers that slide under the bottom board. The arms are held open by a spring and are closed by brackets actuated by the back of the hive.

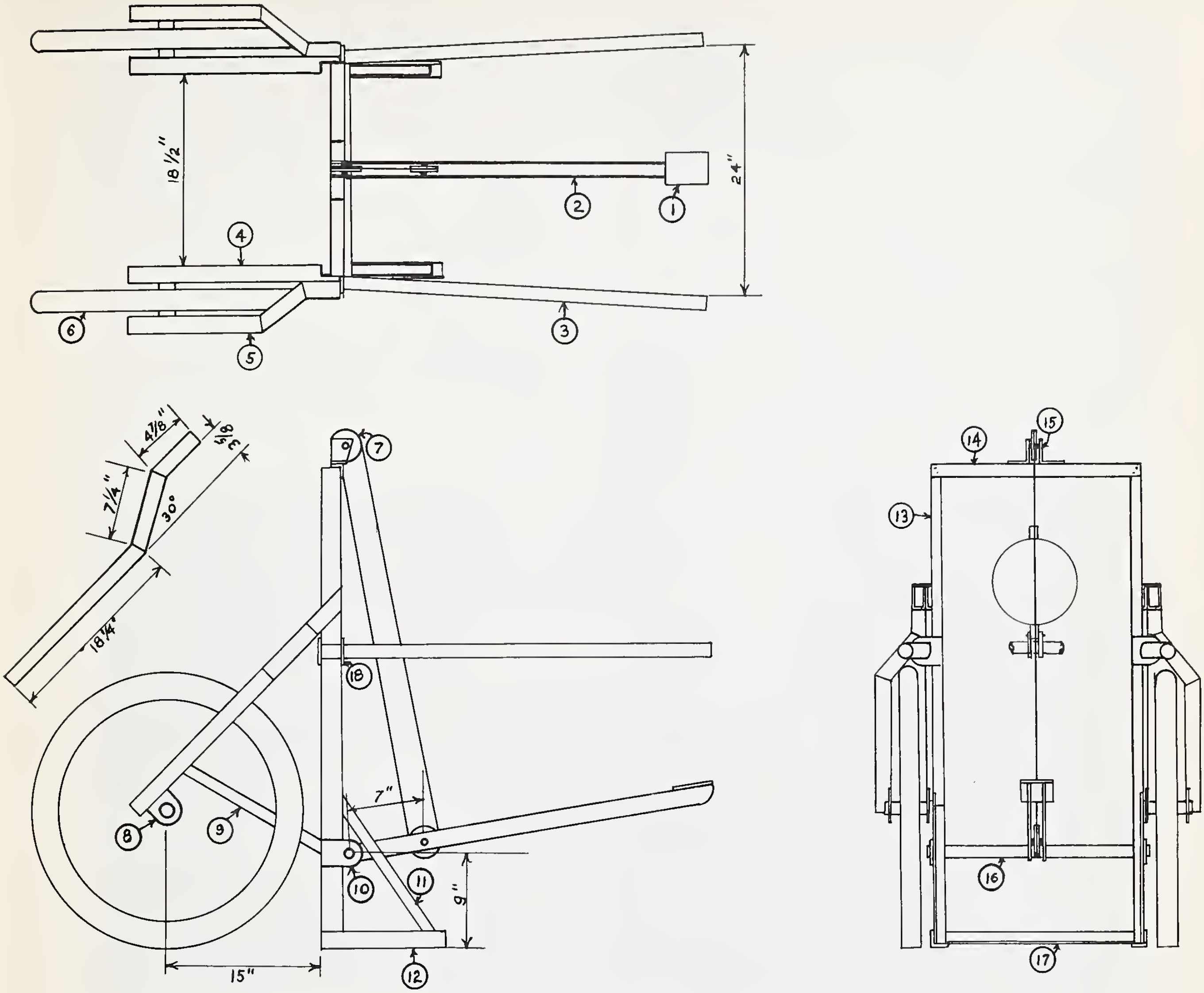

Figure 3.--Main frame of bee hive scale.

The other type of bottom board used is the reversible type. The scale and the reversible bottom board can be modified to use with this scale principle. To use the movable finger design on the reversible bottom board, cleats would be added under each end of the board. A simpler modification would be to place cleats under the sides and use rigid fingers on the lifting frame. The detail of the rigid finger design is shown in Figure 5 (items 30 through 33). The rigid fingers do increase the weight of the scale, but they also simplify the construction and operation. It is desirable to have at least an inch clearance under all bottom boards for fast operation of the scale. Items 19 through 29 (Table 1) make up the lifting frame with movable fingers. When rigid fingers are used, part 22 of the lifting frame is shortened 1 inch and parts 30 through 33 are used. Parts 19, 20, 23, 24, and 25 are omitted when rigid fingers are used.

Figure 4.--Hive scale with compression measuring unit. This was the first model which had small wheels.

Ball bearings are used for radial and thrust loads against the guides to reduce the friction between the guides and the moving frame. If 3-inch channel is used, the main bearings and shafts have to be mounted off center to maintain the movable frame in the vertical position. The top shaft is mounted forward (toward the hive) and the botton shaft backward, each one-half the difference between the bearing outside diameter and the space in the channel.

Two types of measuring elements can be used: One, the tension unit as a spring scale (Figure 1), and the other, a compression element as a hydraulic unit (Figure 4). Both types have been used satisfactorily. The tension type

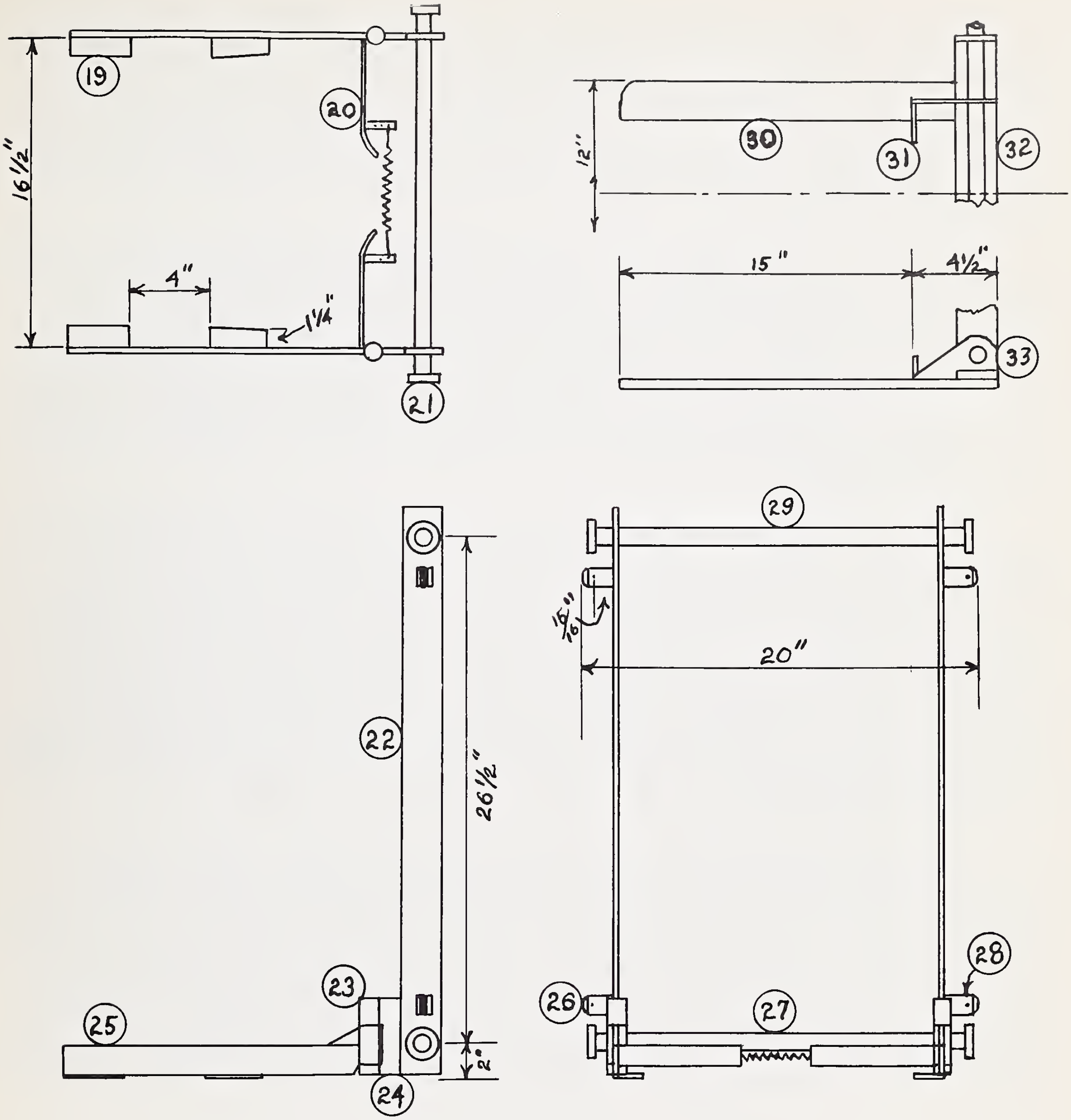

Figure 5.--Lifting frame of bee hive scale.

is cheaper and easier to operate by an inexperienced person. The compression type requires proper alinement of parts to prevent increasing the friction when lifting, whereas the tension scales will tend to reduce the friction on the slides. The principal advantage of the compression-type element is that it reduces the height of the scale about 10 inches. The tare weight of the lifting frame can be compensated for in most scale elements.

A scale using the compression element weighs by pushing down on a foot lever that is pivoted so as to push up on the sensing element and the element pushes up the lifting frame. This places the element in compression that by proper gages will indicate the weight of the hive. The tension element is fastened to the top of the frame and is pulled up by cable arrangement to the foot lever. The foot lever for both types of elements has about 4 to 1 mechanical advantage. Figure 4 shows the construction of a weighing scale that uses a tension element.

If the main and lifting frame of the scale is constructed carefully, the weight will be as accurate as the scale used to measure the weight. For the best accuracy the scale capacity should be only slightly greater than the colonies being weighed. The reason for this is that the elements are rated for accuracy in percentage of full capacity. For example, a 1-percent accurate scale of 200-pound capacity would read ± 2 pounds, and the same accuracy for a scale of 600-pound capacity would read ± 6 pounds. Therefore, weighing a 150-pound hive with the 600-pound scale would be only accurate to 4 percent of the hive weight.

Research workers may desire weighing units that have an accuracy better than 1 percent. Generally, highly accurate spring scales are too large to be used in this type of weighing unit. The hydraulic compression or the strain gage type (compression or tension) will give the accuracy in a small lightweight element. A moderately priced, or even some low-priced, spring scales will be accurate enough for use by all beekeepers and even for some records by research workers. That is, most of the moderate-priced spring scales will read ± 2 pounds, which is close enough for measuring gains when readings are a week or more apart. The highly accurate scale would be needed for hourly or daily gains or where it is necessary to determine small changes in the hive weight.

To weigh, the operator pushes the scale against the hive to force the arms under the hive and then steps down on the foot lever. When the hive clears the ground, the weight is indicated on the dial or gage of the weighing element. Easing up on the foot lever lowers the hive to the ground. Backing the scale away completes the weighing cycle. A hive can be weighed and the weight recorded in less than a minute with all types of elements. Research workers will have a fast and easy means of getting the necessary weights for their research projects. These weight records can help a beekeeper determine whether a location should be changed and what colonies are the best producers.